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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/666,354	09/19/2003	Hui-Lin Chang	TS02-1079	8188

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EXAMINER	
ANGADI, MAKI A	

ART UNIT	PAPER NUMBER
1765	

DATE MAILED: 08/04/2006

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	10/666,354	CHANG ET AL.	
	Examiner	Art Unit	
	Maki A. Angadi	1765	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *19 May 2006*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-34* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☒ Claim(s) *24-34* is/are allowed.

6)☒ Claim(s) *1-23* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date *12/24/2003*.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

DETAILED ACTION

Election/Restrictions

Applicant's election of claims 1-34 in the reply filed on 1/31/2006 is acknowledged. Because applicant did not distinctly and specifically point out the supposed errors in the restriction requirement, the election has been treated as an election without traverse (MPEP § 818.03(a)).

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

1. Claims 1,3, 5, 7-10, 12,13,15, 18-21, 23-25,27, 30-33 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kim (US Pub No. 2002/0106891).

As to claim 1, Kim discloses a method of fabricating a semiconductor device having a low dielectric layer (paragraph 0002) consisting of:

(a) substrate (100) (Fig.2) (paragraph 0035);

(b) forming a low k dielectric layer consisting of an silicon oxycarbide layer (110) (organo-silicon material) on said substrate (paragraph 0035);

(c) Performing a treatment of He plasma on said low k dielectric layer in a process chamber to form a transformed low k dielectric layer (paragraph 0036); and

(d) Performing treatment with H_2 plasma on the transformed low k dielectric layer in a process chamber (paragraph 0048)(Table 1).

Although the reference of Kim discloses that hydrogen and helium are suitable plasmas for forming a layer of an organic polymer group over the regenerated surface of silicon oxycarbide, the reference fails to disclose a specific example wherein a first plasma treatment is conducted using helium plasma gas followed by a second treatment using hydrogen gas.

Kim suggests the use of He, O_2 and H_2 plasma treatment to modify the physical properties of layers (paragraph 0058). Kim, is however silent about the order of the plasma treatment. It is noted that Kim fails to disclose applicant's specific sequence of (a) a first treatment of He plasma and (b) second treatment

of H_2 plasma. However, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the sequence of steps in Kim to include any order of step (a) and (b) because the final product of Kim appears to be similar to the product produced by applicant's claimed sequence of processing steps. Since each step imparts separate and distinct properties to the dielectric material, it appears that a similar product would be produced regardless of the sequence of steps. Ex parte Rubin, 128 USPQ 440 (Bd. App. 1959).

As to claim 3, Kim discloses low k dielectric layer consisting of doped silicon oxide (paragraph 0058), hydrogen silsequioxane (HSQ), or methysilsequioxane (MSQ) (paragraph 0005).

As to claim 5, Kim discloses the use of plasma enhanced CVD (PECVD) for plasma treatment (paragraph 0062).

As to claim 7, Kim discloses the plasma treatment during a period of about 10-200 seconds (paragraph 0048) that overlap the values disclosed by the applicant.

As to claim 8, 18 and 30 Kim discloses the process chamber pressure in the range of about 1 to 10 Torr (paragraph 0048) that overlap the range disclosed by the applicant.

As to claim 9, 19 and 32 Kim discloses the plasma treatment with RF power of about 200 Watts that is close to the value disclosed by the applicant. Therefore, it would be obvious to one of ordinary skill in the art at the time of invention to select the RF power suggested by the applicant because Kim suggest that the process parameters can be changed according to the treatment conditions of subsequent process of a semiconductor device (paragraph 0048).

As to claim 10 and 20, Kim discloses that the substrate is heated between 250 to 400°C that overlaps the range suggested by the applicant.

As to claim 12, Kim discloses wherein the transformed low k dielectric layer (silicon oxycarbide layer) is enriched with Si-H bonds during the H_2 treatment (paragraph 0048).

As to claim 13, Kim discloses a method of lowering the dielectric constant and increasing the thermal and mechanical stability of a low k dielectric layer in a damascene process (paragraph 0051), consisting of:

(a) Providing a substrate having an etch stop layer (131)(Fig.7 and 8) (paragraph 0052);

(b) Depositing a low dielectric layer consisting of an organosilicon compound (111)(Fig. 7 and 8) (paragraph 0051)

(c) Performing a first treatment consisting of He plasma on said low k dielectric layer in a process chamber to form a transformed low dielectric layer (paragraph 0062).

(d) Performing a plasma treatment with H2 plasma on transformed low k dielectric layer for form a composite low k dielectric layer consisting of a transformed low k dielectric layer that is enriched in Si-H bonds (paragraph 0048) on a transformed low k dielectric layer that has a mechanically stabilized network of Si-O bonds (paragraph 0049).

(e) Forming an opening/hole in the composite low dielectric layer that extends through said etch stop layer (paragraph 0051); and

(f) Depositing a diffusion barrier layer on the sidewalls of said opening/hole, depositing a metal layer on said barrier that fills said opening/hole, and planarizing said metal layer and said diffusion barrier layer to a level that is coplanar with the composite low k dielectric layer (paragraph 0052).

Although Kim suggest the use of He plasma treatment in the formation of low k dielectric material, does not expressly disclose its use in the damascene process as claimed by the applicant.

Kim suggests the use of He, O_2 and H_2 plasma treatment to modify the physical properties of layers (paragraph 0058). Kim, is however silent about the order of the plasma treatment. It is noted that Kim fails to disclose applicant's

specific sequence of (a) a first treatment of He plasma and (b) second treatment of H_2 plasma. However, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the sequence of steps in Kim to include any order of step (a) and (b) because the final product of Kim appears to be similar to the product produced by applicant's claimed sequence of processing steps. Since each step imparts separate and distinct properties to the dielectric material, it appears that a similar product would be produced regardless of the sequence of steps. Ex parte Rubin, 128 USPQ 440 (Bd. App. 1959).

As to claim 15, Kim discloses that the thickness of low k dielectric layer is consisting of carbon doped silicon oxide layer is about 5000 Å (paragraph 0059).

As to claim 21, Kim discloses that low k dielectric layer enriched in Si-H bond has a thickness from about 5000 Å (0059).

As to.claim 23, Kim discloses the use of Ti/TiN as the barrier metal layer and copper metal layer (paragraph 0057).

As to claim 24, Kim discloses a method of lowering the dielectric constant and increasing the thermal stability and mechanical stability of a low k dielectric layer in an interconnect structure (paragraph 0052);

(a) Providing a substrate (100) with a metal layer consisting of metal lines having top surface with sidewall (160) formed thereon and ant-reflective coating (ARC)(131) formed on the top surface (paragraphs 0050 and 0052);

(b) Depositing an oxide layer such as PETEOS (paragraph 0051);

(c) Depositing a low k dielectric layer consisting of organosilicon material by CVD or PECVD method (0047)

(d) Curing the low k dielectric layer (paragraph 0054);

(e) Performing a plasma treatment with H_2 plasma on transformed low k dielectric layer for form a composite low k dielectric layer consisting of a transformed low k dielectric layer that is enriched in Si-H bonds (paragraph 0048) on a transformed low k dielectric layer that has a mechanically stabilized network of Si-O bonds (paragraph 0049).

Although Kim suggests the use of He plasma treatment in the formation of low k dielectric material, does not expressly disclose its use in the damascene process as claimed by the applicant.

Kim suggests the use of He, O_2 and H_2 plasma treatment to modify the physical properties of layers (paragraph 0058). Kim, is however silent about the order of the plasma treatment. It is noted that Kim fails to disclose applicant's specific sequence of (a) a first treatment of He plasma and (b) second treatment of H_2 plasma. However, it would have been obvious to one of ordinary skill in the

art at the time the invention was made to modify the sequence of steps in Kim to include any order of step (a) and (b) because the final product of Kim appears to be similar to the product produced by applicant's claimed sequence of processing steps. Since each step imparts separate and distinct properties to the dielectric material, it appears that a similar product would be produced regardless of the sequence of steps. Ex parte Rubin, 128 USPQ 440 (Bd. App. 1959).

As to claim 25, Kim discloses the process that consist of planarizing the low k dielectric layer (paragraph 0052).

As to clam 27, Kim discloses low k dielectric layer consisting of doped silicon oxide (paragraph 0058), hydrogen silsequioxane (HSQ), or methysilsequioxane (MSQ) (paragraph 0005) and has thickness of about 5000 Å (paragraph 0059).

As to claim 29, Kim discloses the duration of plasma treatment from about 30-50 second (paragraph 0048) that overlap the range cited by the applicant. Kim does not specifically cite the gas flow rate. However, Grill discloses the precursor flow rate at between 5-200 sccm (col.3, lines 35-36). According to Grill, the films can be prepared by choosing a suitable precursor and a specific combination of processing parameters such as flow rate, pressure in reactor and substrate temperature (col.5, lines 38-42) that can be optimized to obtain low-k

films. See MPEP § 2144.05 II. One who is skilled in the art would be motivated to optimize gas flow rates through routine experimentation.

As to claim 30, Kim discloses the process chamber pressure in the range 1 to 10 Torr (paragraph 0048) that overlap the values disclosed by the applicant.

As to claim 31, Kim discloses the plasma treatment with RF power of about 200 Watts that is close to the range disclosed by the applicant. Therefore, it would be obvious to one of ordinary skill in the art at the time of invention to select the RF power suggested by the applicant because Kim suggest that the process parameters can be changed according to the treatment conditions of subsequent process of a semiconductor device (paragraph 0048).

As to claim 32, Kim discloses that the substrate is heated between 250 to 400°C that overlaps the range suggested by the applicant.

As to claim 33, Kim discloses that low k dielectric layer enriched in Si-H bonds has a thickness from about 5000 Å (0059).

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

2. Claims 2, 4, 6 11, 14, 16, 17, 22, 28, 29 and 34 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kim (US Pub No. 2002/0106891)(see teachings of Kim above) in view of Grill (US Patent No. 6,147,009).

As to claim 2 and 14, Kim does not specifically disclose the process of curing the low k dielectric layer before performing the He plasma treatment. However, Grill discloses the heat treatment (curing) of film at a temperature not less than 300°C (col. 3, lines 1-2). Therefore, it would be obvious to one of ordinary skill in the art at the time of invention to select curing of dielectric layer because Grill reveals that curing process improves the stabilization of low-k film (col.7, lines 9-13). The selection of any order of curing is prima facie obvious. Ex parte Rubin, 128 USPQ 440 (Bd. App. 1959).

As to claim 4, 16 and 28 Kim is silent about the atomic percentage ratios in the composition of SiCOH. However, Grill discloses the composition of SiCOH: about 5-40 atomic % of Si; about 5-45 atomic percent of C; about 0-50 atomic percent of O; about 10-55 atomic percent of H that overlap the atomic percent of compositions selected by the applicant (col.6, lines 25-33). Therefore, it would be obvious to one of ordinary skill in the art at the time of invention to modify the atomic percent of components because Grill illustrates that the atomic percent of

compositions would determine thermal stability of low dielectric constant materials suitable for integration in a BEOL wiring structure (col.5, lines 12-17).

As to claim 6, 17 and 29 Kim does not expressly disclose the gas flow rate. However, Grill discloses the precursor flow rate at between 5-200 sccm (col.3, lines 35-36). According to Grill, the films can be prepared by choosing a suitable precursor and a specific combination of processing parameters such as flow rate, pressure in reactor and substrate temperature (col.5, lines 38-42) that can be optimized to obtain low-k films. See MPEP § 2144.05 II. It would have been obvious to one of ordinary skill in the art to select any flow rate in the process of Kim, including applicant's flow rate in calim 6, because reference of Grill illustrates that flow rate is a parameter which can be optimized to obtain a low k film.

As to claim 11, Kim discloses the one or more gases selected from the group of He, H_2, O_2 and Ar in a substrate-loaded processing chamber (paragraph 0022). Kim does not expressly disclose whether the plasma treatment of different gases is done without breaking chamber vacuum. Grill discloses the use of in-situ process for annealing and depositing of low k dielectric material to enhance the thermal stability of films (col.7, lines 1-13). Therefore, it would be obvious to one of ordinary skill in the art at the time of invention to perform first and second treatment in the same chamber without breaking chamber vacuum in the process

of Kim because Grill suggests that in-situ process can enhance thermal stability of the low k dielectric films (col.7, lines 15-18).

As to claim 17 and 29, Kim discloses the duration of plasma treatment from about 30-50 second (paragraph 0048) that overlap the range cited by the applicant.

As to claim 22 and 34 Kim does no expressly reveal the plasma treatment of first and second type in the same process chamber. Grill discloses the use of in-situ process for annealing and depositing of low k dielectric material to enhance the thermal stability of films (col.7, lines 1-13). Therefore, it would be obvious to one of ordinary skill in the art at the time of invention to perform first and second treatment in the same chamber because Kim suggests that in-situ process can enhance thermal stability of the low k dielectric films (col.7, lines 15-18).

Claim Rejections - 35 USC § 103

3. Claim 26 is rejected under 35 U.S.C. 103(a) as being unpatentable over Kim (US Pub No. 2002/0106891) (see teachings of Kim stated above) in view of Wolf, Silicon Processing for the VLSI Era Vol.1, page 441, Lattice Press (1986).

Kim discloses the use of TiN a metal barrier layer (paragraph 0052) without citing its use as ARC layer. However, Kim has disclosed the use of SiN layer (0050) that can be used as ARC layer. However, Wolf has discussed the

use of several ARC layer. Therefore, it would be obvious to one of ordinary skill in the art at the of invention to select ARC layers in the damascene structure disclosed by Kim because Wolf illustrates that ARC partially planarizes the wafer topography, further helping to improve line-width variation over steps, since the resist thickness is more uniform (page 441).

Response to Arguments

4. Applicant's arguments filed on 5/19/2006 have been fully considered and are persuasive in overcoming the 102 rejection over Kim. However, upon further consideration a 103 rejection is made over Kim. Kim discloses the plasma treatment by H_2 plasma and He plasma treatments (see Table I on page3). Kim discloses the relative dielectric constant resulting from performing the plasma treatment of several types under the same conditions with the preferred embodiment after forming the silicon oxycarbide layer. Kim concludes that the plasma treatment does not have significant influence on the relative dielectric constant of the silicon oxycarbide layer (paragraph 0044). As a result, any combination of plasma treatments with the disclosed known plasma would produce similar results in the absence of unexpected results. Since both hydrogen and helium are suitable, a process involving both plasmas would not distinguish a process using a single plasma.

Therefore, Claims 1-23 stand rejected.

Allowable Subject Matter

Claims 24-34 are allowable.

5. The following is a statement of reasons for the indication of allowable subject matter: The closest prior art of Kim (US Pub.No. 2002/0106891) does not teach or suggest "providing a substrate with a metal layer comprised of metal lines having a top surface and sidewalls formed thereon and an anti-reflective coating (ARC) formed on the top surface of said metal lines".

Claims 24-34 are allowable.

Conclusion

The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. Chen (US Patent No. 5,858,869) discloses a method for fabricating inter-metal dielectric insulation using anisotropic plasma oxides and low dielectric constant polymers.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Maki A. Angadi whose telephone number is 571-272-8213. The examiner can normally be reached on 8 AM to 4.30 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nadine G. Norton can be reached on 571-272-1465. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300. Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private

PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

Dr. Maki Angadi
Examiner
Art Unit 1765

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